PSEUDOMORPHIC CHONDRULES IN HYDRATED FINE-GRAINED MICROMETEORITES –AND THE IDENTIFICATION OF A NEW HYDRATED PARENT BODY

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Introduction: Hydrated fine-grained micrometeorites are the most abundant subtype of cosmic dust across the entire size range of the flux (50-3000µm)[1,2,3]. They are chondritic particles dominated by Fe-Mg phyllosilicates and may contain as minor components: partially replaced anhydrous silicates (forsterite, enstatite and augite), magnetite, Fe-sulfides and refractory spinels. Despite these significant atmospheric entry overprints, parent body textures are commonly preserved and identifiable[4]. Recently we demonstrated the ability to identify relict coarse-grained components, including pseudomorphic chondrules and altered CAIs. This required that some fine-grained micrometeorites have experienced intense aqueous alteration on their parent bodies[5].

Here we provide the first rigorous statistical analysis of chondrule properties among the fine-grained micrometeorite population. We analyze 42 chondrules within 25 giant (>400µm) micrometeorites using a combination of SEM-BSE, EDX/EMPA and µCT. In addition, we investigate a single micrometeorite (TAM19B-7) containing multiple replaced chondrules in further detail using O-isotope systematics (collected by laser fluorination mass spectrometry at the Open University, UK).

Results: Chondrules in fine-grained micrometeorites are predominantly pseudomorphic (47.6%), with partially altered (11.9%) and unaltered (40.9%) types also identified. They range in size from 24-384µm diameter with a mean average of 148µm and a median average of 130µm. Fine-grained rims are present in just 29% of chondrules and have thicknesses of <107µm and a median average thickness of just 13µm. Among the intact chondrules only POP and PO varieties are recognized.

TAM19B-7: We investigated a single particle (TAM19B-7) further owing to its exceptionally large size (2017µm [avg. diameter]) and the presence of three pseudomorphed, squashed chondrules with notable fine-grained rims. Chondrules in this particle appear to be POP varieties which vary in size from 143-183µm and have homogenous rims (<20µm thick). These chondrules have aspect ratios of 1.1-1.3 (oblate shapes), while the matrix phyllosilicates demonstrate a clear petrofabric, consistent with the direction of chondrule alignment[6]. Bulk triple O-isotope data yielded the following values: δ17O=1.094, δ18O=1.126 and Δ17O=0.508. This particle therefore plots above the terrestrial fractionation line (TFL) and far from the fields of established hydrated chondrite groups (CM, CR, CI), including prominent ungrouped representatives such as C2 Tagish Lake. Although TAM19B-7 is intensely weathered, resulting in partial equilibration with Antarctic water, which lowers its pre-atmospheric δ18O value, weathering cannot draw the O-isotope signature above the TFL. TAM19B-7, therefore does not appear to be associated with any known hydrated chondrite group.

Discussion: Recognizable chondrules in fine-grained micrometeorites are exclusively small (<400µm). Their average size best matches the CO group (150µm) while values also extend towards the average diameter of CM chondrites (300µm)[7]. Large chondrules, consistent with the average size in CR chondrites (~700µm)[7] are not observed. However, O-isotope and geochemical data have previously identified CM/CR representatives[8,9], therefore, sampling biases and fragmentation dynamics clearly play a significant role removing the largest chondrules, which will instead appear among the flux as coarse-grained micrometeorites.

Despite these effects, this study clearly demonstrates two factors: (1) that fine-grained micrometeorites contain abundant small chondrules, including microchondrule representatives (<40µm diameter) and that (2) where present these chondrules tend to be heavily affected by alteration replacement (in 59.5% of cases). These findings extend the conclusions of our previous study - based on 5 giant micrometeorites[5]. Here we argue, based on a significantly larger population that that much of the fine-grained micrometeorite flux originates from intensely altered C-type asteroids.

In addition, data from TAM19B-7 provides strong evidence that fine-grained micrometeorites sample a range of parent bodies, including those not present among meteorite collections. This new group is characterized by extreme aqueous alteration, equivalent to the C1 petrologic subtype combined with a prominent petrofrabric, implying impact events were the source of heat energy driving aqueous alteration on this asteroid.

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